Calibrating Large Photometric Surveys Using Hot White Dwarfs

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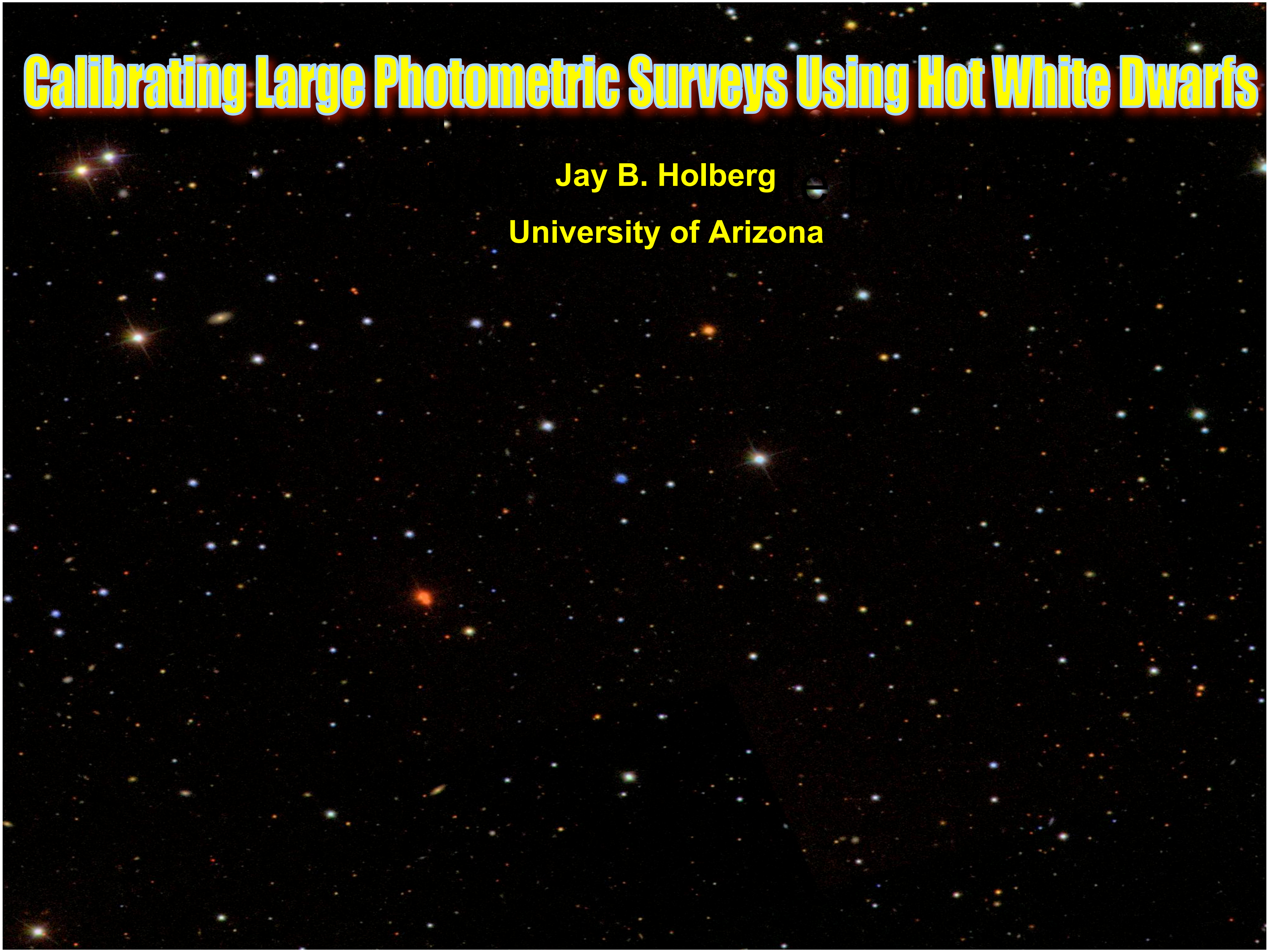


DA White Dwarfs and Synthetic Photometry

I. DA White Dwarfs Placed on the HST Photometric Scale

Holberg & Bergeron (2006) AJ, 132, 1221

II. DA White Dwarf Distances

Holberg, Bergeron & Gianninas (2008) AJ, 135, 1239

Topics

I. DA White Dwarfs as Absolute Flux Standards

(Synthetic Photometry)

II. Estimating the Projected Density of White Dwarfs on the Sky

Synthetic Photometry

$$f_\lambda = 4\pi H_\lambda(T_{eff}, \log g)\left(R^2 / D^2\right)$$

f_λ = *Observed flux at the top of the Earth's Atmosphere*

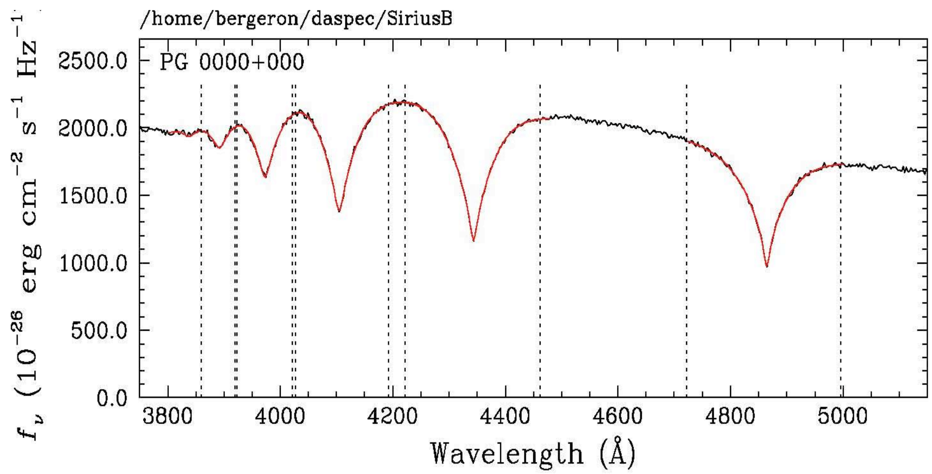
$H_\lambda(T_{eff}, \log g)$ = *Eddington Flux at the Stellar Surface*

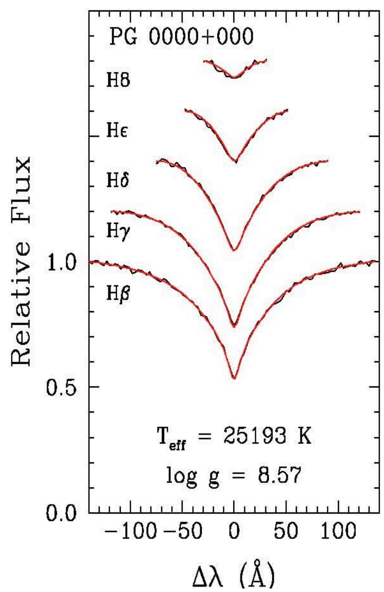
R = Stellar Radius (Mass-Radius Relation)

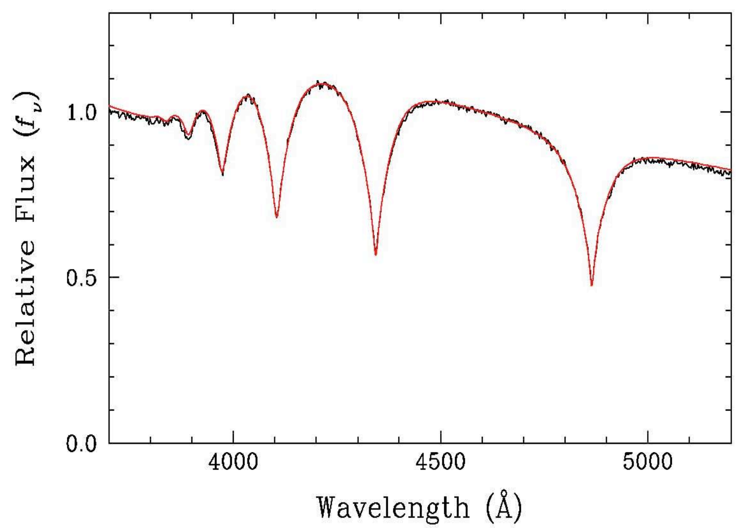
D = Stellar Distance

Spectral Fitting for T_{eff} and log g

Sirius B







Absolute Magnitudes

$$F_s = \frac{\int f(\lambda) S(\lambda) d\lambda}{\int s(\lambda) d\lambda}$$

Stellar flux integrated over band-pass

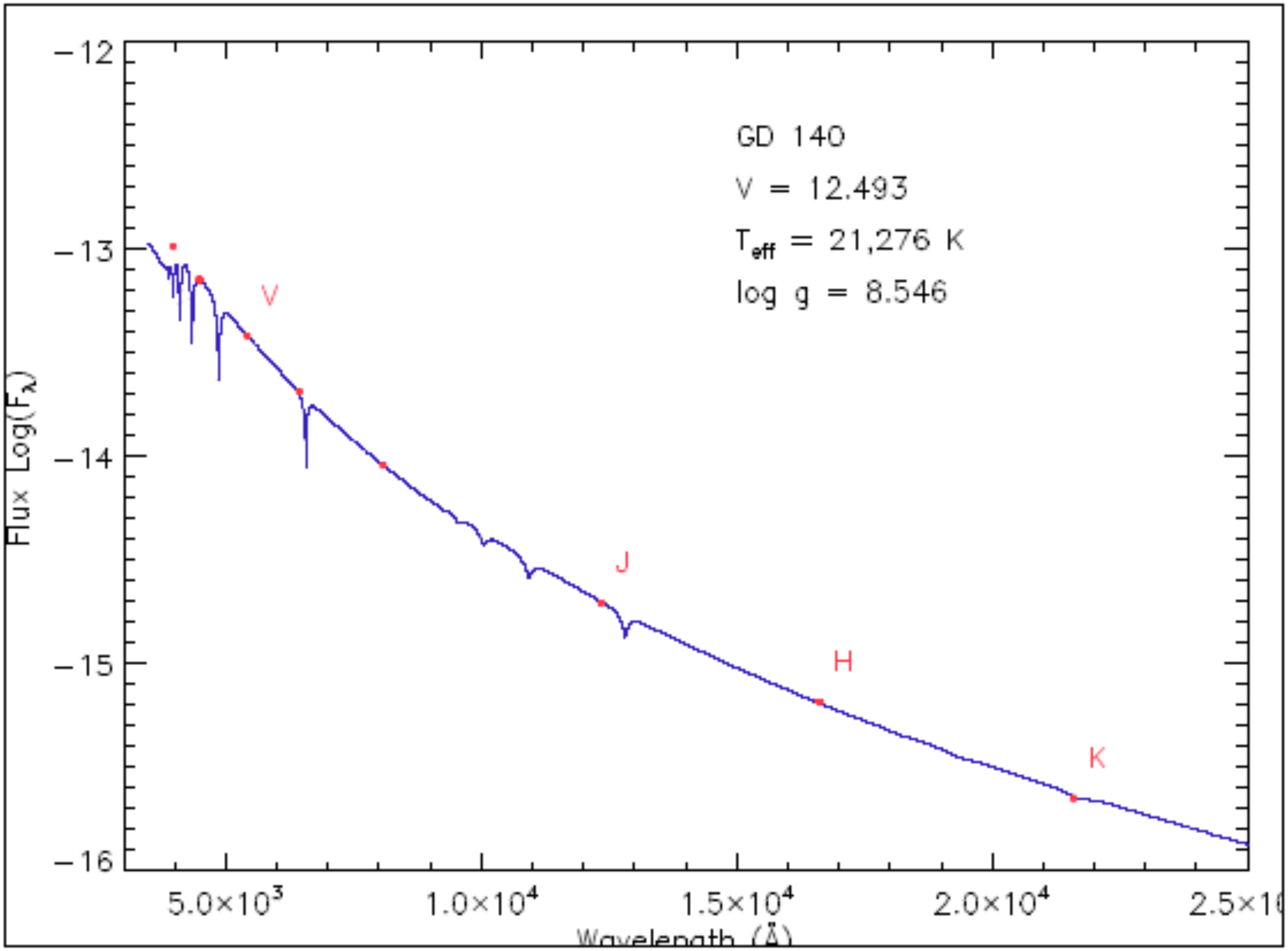
$$M_s = -2.5 \log(F_s) + C_s$$

Synthetic Magnitude for band-pass S

The constant C_s can be defined with respect to Vega

For DA white dwarfs C_s can be defined so that M_s is the absolute magnitude for band pass S as function of T_{eff} and log g. Note this requires knowledge of the relative response of the band-pass.

Example



GD 140
V = 12.493
T$_{eff}$ = 21,276 K
log g = 8.546
V
J
H
K
Flux Log(F$_\lambda$)
Wavelength (Å)
−12
−13
−14
−15
−16
5.0×10^3
1.0×10^4
1.5×10^4
2.0×10^4

Example

GD 140 (WD 1134+300)

T_{eff} = 21,276 K & log g = 8.545

Abs Mag.	MU	MB	MV	MR	MI	MJ	MK	MH
Synth	10.464	11.477	11.545	11.661	11.778	12.080	12.151	12.233
Obs	**U**	**B**	**V**	**R**	**I**	**J**	**K**	**H**
	11.377	12.400	12.493	12.603	12.723	12.993	13.105	13.183
Obs-Syn	0.913	0.923	0.948	0.942	0.945	0.913	0.945	0.950

Ave (O-S) = 0.934

*** http://www.astro.umontreal/~bergeron/CoolingModels**

Distances

$\mu = M_{obs} - M_{abs}$ **Distance Modulus**

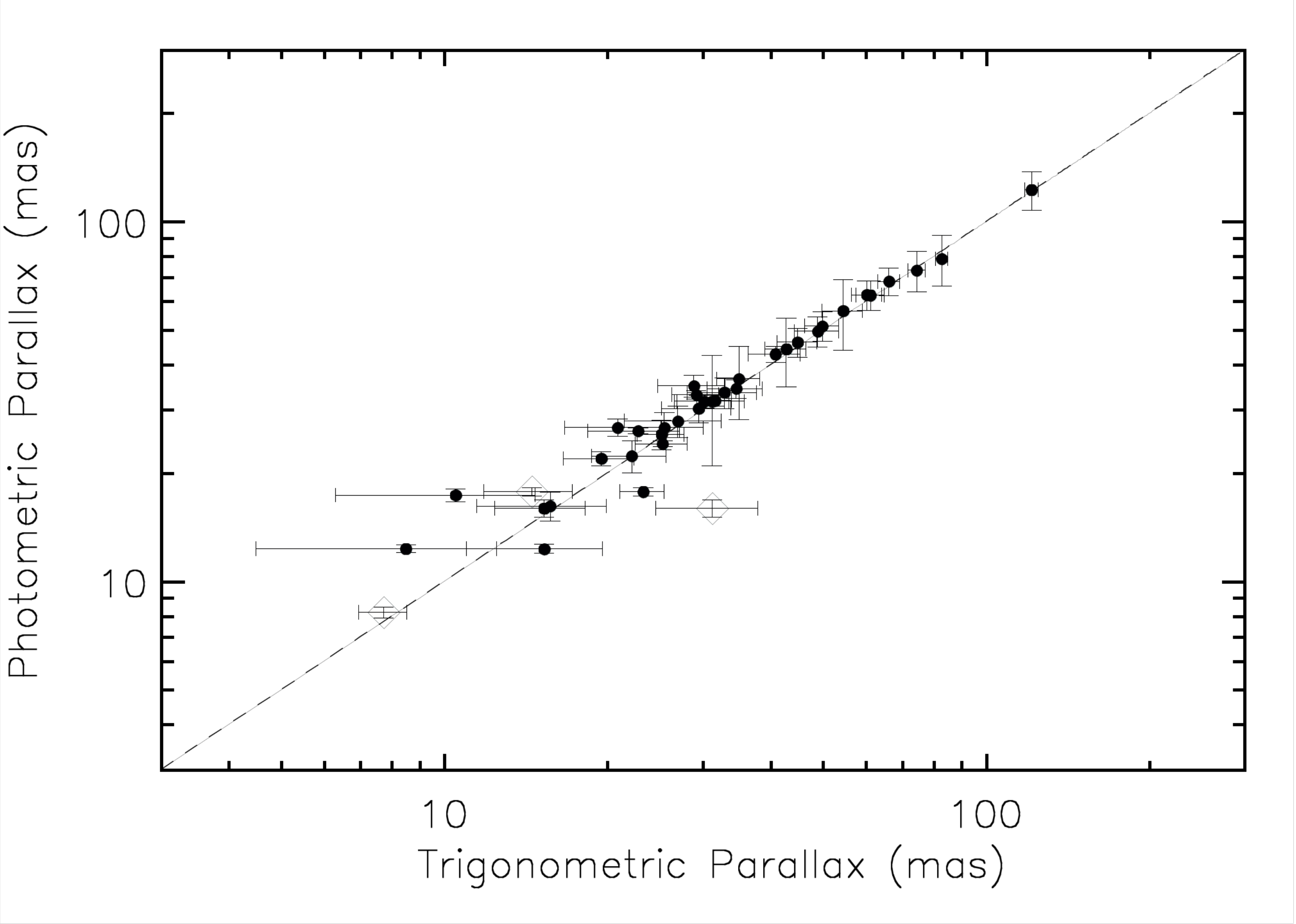
$D = 5\log(\mu / 10)$ **Distance (pc)**

GD 140 (UBVRI+JHK) D = 15.38 ± 0.25 pc

GD 140 (ugriz) D = 15.44 ± 0.25 pc

GD 140 1/π (*Hipparcos*) D = 15.32 ± 0.63 pc

Correlation of ‘Photometric Parallaxes with Trigonometric Parallaxes



Estimating the Areal Density of Hot White Dwarfs

$$N(b^{II}) = n_0 f \frac{h^3 d\Omega}{Sin(b^{II})^3}$$

No. of Hot WDs/sq. deg.

b^{II} : Galactic Latitude

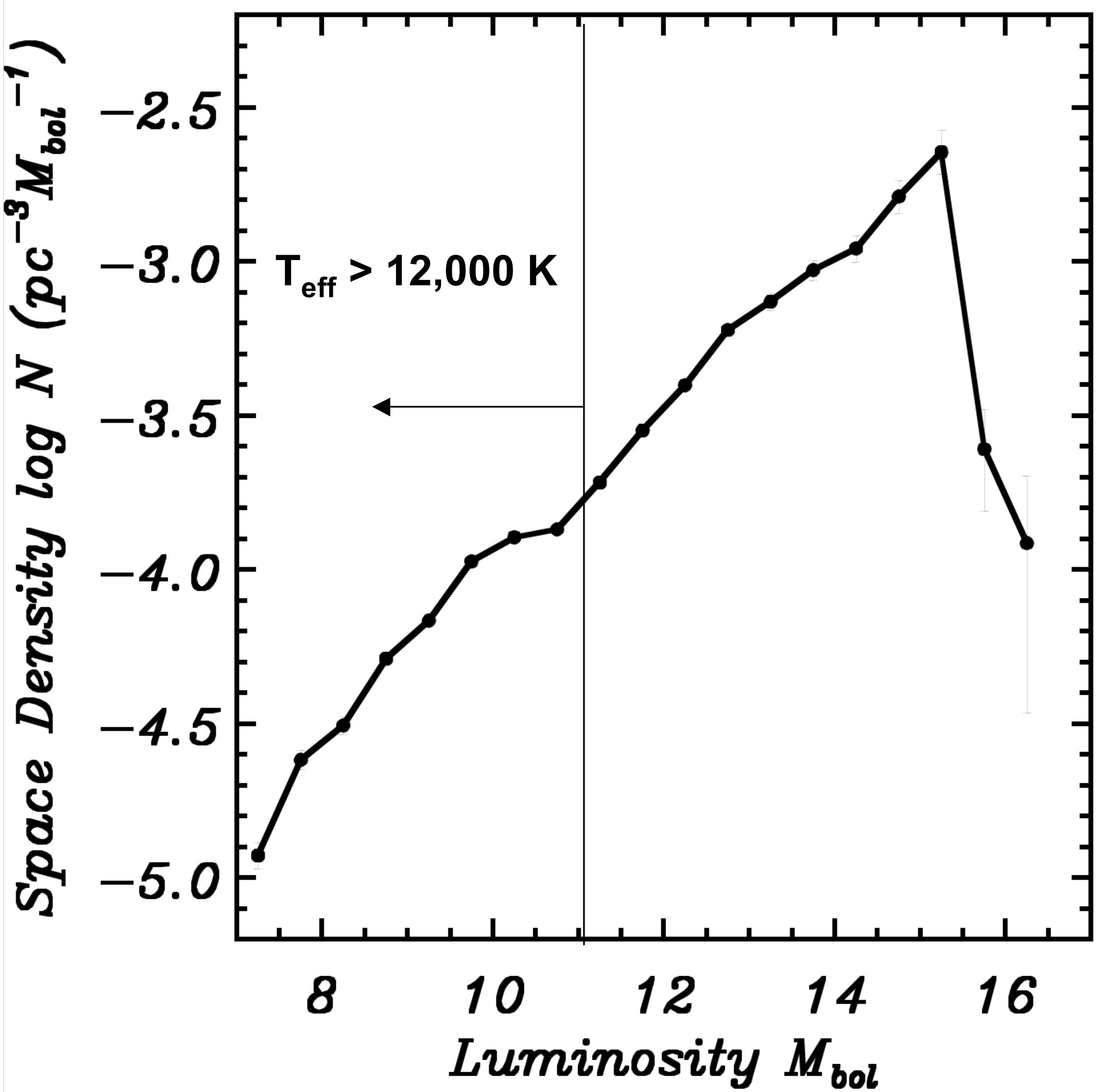
h : Galactic Scale Height of WDs

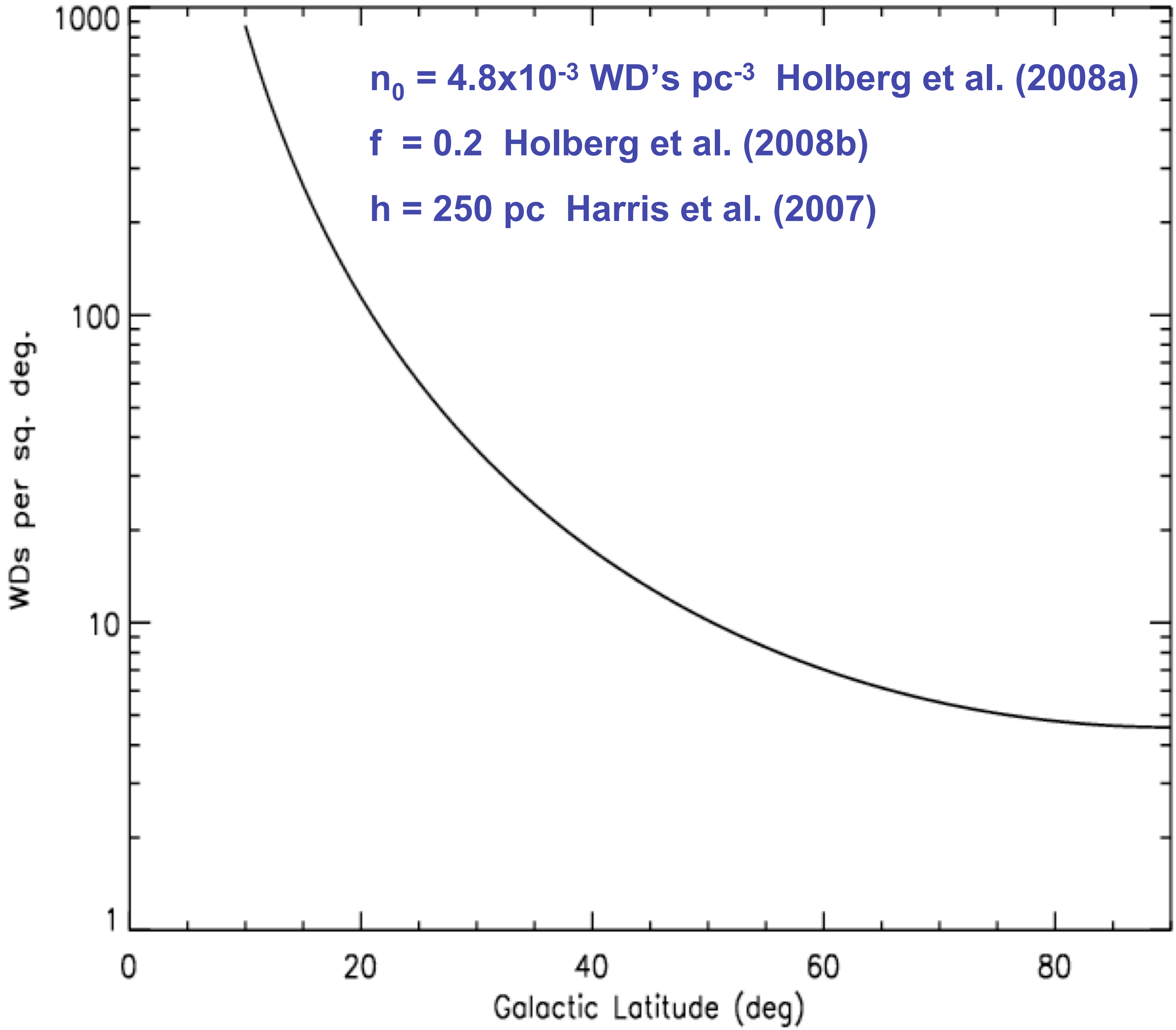
n_o : Local Space Density of WDs[1]

f : Fraction of Hot WDs

[1] Holberg, et al. (2008b) AJ, 135, 1225

Harris et al. (2007) Luminosity Function





n_0 = 4.8x10^{-3} WD's pc^{-3} Holberg et al. (2008a)
f = 0.2 Holberg et al. (2008b)
h = 250 pc Harris et al. (2007)
WDs per sq. deg.
1000
100
10
1
0
20
40
60
80
Galactic Latitude (deg)

Summary

- **Calibrations based on DA white dwarfs have a <u>Strong Physical Basis</u>**
- **They are applicable from the UV (and X-ray) into the Near IR**
- **They are widely distributed in magnitude and over the sky**
- **Photometric calibrations based on white dwarfs should be easy to compare between different large surveys and different filters.**

Other Considerations

- In general white dwarfs are blue objects
- They may not be sufficiently densely distributed over the sky so that there is a suitable standard in every field.